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FACILITATION OF UNIVERSITY TECHNOLOGY TRANSFER THROUGH A COOPERATIVE SERVICE-UNIVERSITY-INDUSTRY PROGRAM

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13. ABSTRACT *(Maximum 200 words)*

This paper presents two university-based programs to facilitate technology transfer from universities to the military services and industry. First, through technology transfer centers for applied engineering training and consulting, and second, in assisting and expanding university technology transfer incubator programs. These programs would require minimal new funding by the services, being based upon co-funding and support from industry, universities, and venture capital groups. The programs would offer the following five benefits to the military services and private industry: 1) provide both the services and industry with an applied engineering program and the training for new engineers and researchers, 2) serve as an information resource for both the services and industry on new technologies, 3) provide industry with both advanced knowledge and laboratory resources, 4) provide management and marketing support for small technology firms, and 5) expand the base of possible new technologies for inclusion in military systems.

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Introduction

The proposals in this paper were developed to address several Service concerns that were not being resolved either through current legislation or programs. First among these concerns was the probable implementation gap between basic R&D research performed in Government Labs and Universities and its subsequent commercialization. Second, that there will be a continuing decrease in funding for Government Labs, Universities and DoD weapons systems, and as a result, the Services, Industry and Universities need to look at ways to pool and stretch their resources. Lastly, there exists a need to incorporate the latest "leading edge" technologies in DoD weapons systems, to retain technological superiority on the battlefield.

In looking at these concerns, it seemed that the most promising area that the Services could influence would be that of the research potential found in our major universities, which, while funded by numerous DoD and Service programs, still seemed to hold vast untapped resources that could benefit Services' research and that of private industry. Through discussions with university personnel (University of Texas at Austin and Massachusetts Institute of Technology) and private industry, two university based approaches seemed best fitted to provide access to university research, develop business attuned engineers, and promote small start-up companies which are most likely to provide specialty engineering and items to the Services. The first program would be to establish technology transfer centers for applied engineering and consulting, where the government would establish pilot masters' degree programs in applied engineering to support technology transfer. These centers would be jointly funded by the Services, Industry and the Universities where they were established, and would serve as basic building blocks to establish technology transfer in an area were substantial research is currently being performed but not fully utilized. The second program would assist and expand existing university technology transfer incubators to fully utilize the potential that exists at the university for new approaches in science and technology, and to aid new start-up companies.

These Programs would be good for the Services and the acquisition community for several reasons. First, they would make aware to both Service and industry students the issues concerning technology transfer and product development for both industry and government. Next, the students would learn about the opportunities and risks associated with inserting high technology into new programs. The students would also gain a view into the testing process for certification of new products. The Services would further gain engineers versed in the coordination between private industry and the Services. Lastly, the Services and private industry would gain additional new companies for specialty engineering.

History

For many years, there has been an active effort to promote technology transfer, as reflected by the following programs:

<u>Stevenson-Wydler Technology Innovation Act (1980)</u>, called for the establishment of Offices of Research and Technology Application within most federal laboratories to identify technologies with commercial potential and facilitate their transfer to the private sector. It also

called for more explicit federal involvement in developing and disseminating commercially relevant technology to small businesses and individuals.

Bayh-Dole Act of 1980, permitted universities, not-for-profits, and small businesses to obtain title to inventions developed with government support.

Small Business Innovation Research Program (SBIR) 1982, provides funding and technical direction for small business. Its overall objectives were to stimulate technological innovation and to use small businesses to meet federal R&D needs. Small businesses are selected based upon a source selection evaluation by the Government. The program has three phases: (1) a six-month contract for less than $100K is awarded to perform feasibility studies, (2) then a contract is let for research, development and prototype production up to $750K, (3) finally, the product is marketed or produced using private sector funding.

National Cooperative Research Act (1984), passed to modify the Sherman Antitrust Act to allow companies to pool their resources and efforts in pre-competitive research. Enacted to allow alliances such as the Microelectronics and Computer Technology Corporation (MCC) to form, so as to compete with the Japanese computer industry.

The Federal Technology Transfer Act of 1986, created a uniform policy across agencies, authorizing government-operated laboratories to enter into cooperative R&D agreements (CRADA's) with other organizations (i.e., federal agencies, nonprofit organizations, state and local governments, and private firms). It also permitted agencies to award title to any patents resulting from a CRADA program to the participating outside party. It further provided for cash awards and royalty sharing to encourage federal employees to promote technology transfer. CRADA's have worked well with big companies, but not well with mid-sized and small industries (Bennett, 1993). Currently, there are some 332 working CRADA's at the top three federal labs (Los Alamos 80, Livermore 100 and Sandia 152), not counting the smaller labs that would bring the total up to around 1,000 in all.

Establishment of Sematech (1987), an R&D consortium funded half by DoD and half by private member firms, to regain lost ground in computer processing capability.

Omnibus Trade and Competitiveness Act (1988), called for new programs, with an explicit focus on the generation and diffusion of commercially relevant technology.

National Competitiveness Technology Transfer Act of 1989, enabled federal labs to grant title or licenses for government inventions under cooperative agreements, to wave ownership rights of intellectual property, and to receive royalties. Under cooperative programs, technology developed by federal labs can be protected from public disclosure for up to five years, and trade secrets and proprietary company information are also protected.

National Institute of Standards and Technology, Advanced Technology Program (ATP) 1990, provided cost-sharing support to industry to promote promising, high-risk, high-potential technologies.

Defense Authorization Act of 1991, established model programs for national defense laboratories, and provided for federal laboratories to enter into a contract to perform services related to cooperative or joint small business activities.

Advanced Research Projects Agency (ARPA), Technology Reinvestment Project (TRP) (1994), which provides matching funds to businesses and universities to develop promising new technologies that have commercial and defense applications, and provide manufacturing and technology assistance to small business.

Federal Acquisition Streamlining Act (1994), changed many procurement and reporting procedures to make the acquisition process less restrictive to small business and small purchases. Stressing use of off-the-shelf products, and simplified procedures for procuring them. Expanded the use of Best-value procurements and the role of past performance by the contractor in the source selection process.

These programs have tried to address problems with transferring technology from the R&D stage to a commercial or industrial use. Many times, this process has failed due to the inability of the company to recognize how a new concept or product might be used, or have felt that the profitability of the item would be too low compared to their current product line. However, there are several examples of where technology transfer has worked. These principally have been in either spin-off companies formed by a major company or consortium, alliances formed to assist or manage new small firms, or through individuals' deciding to start their own small company based upon research either they have performed or they feel can be made marketable. These small firms have been successful for perhaps three reasons: motivation, cost controls and focus. Because the individuals involved in these small enterprises recognize that their success, both in terms of their satisfaction and monetary gain, are dependent on making the company succeed, they are highly motivated to put in the needed effort to achieve a viable product; and as a smaller enterprise they are more conscious of the costs and process required in bringing the item to market. Preston (1992) also takes this same view, stating that it is in small companies that we should expect to see the implementation of new technologies and techniques. However, small companies have been vulnerable to failure more so than larger companies. This could be attributed to their lack of prior business/management experience, since many of the start-up principals were either engineers or scientists. Recently, a large number of business "incubators" have been formed to facilitate the maturation process of small firms. These incubators provide management, marketing and legal support until the companies can achieve sufficient momentum on their own to market their products, and also assist them in finding private funding. This approach appears to be working, and the number and scope of these incubators are rapidly increasing. I will discuss how the Services could facilitate this process later in the paper.

There is a need to look at ways to improve quality, lower costs, and move quickly from the concept stage to full-scale production, with the thought of continuous improvement in the product design and in its production processes (Kaminski, 1995; Reich, 1989; STAR21 paper,

1994). As Deputy Defense Secretary Deutch (Deutch and Jones, 1994) has announced, there is also a need to take a proactive stance in the development and use of dual technologies (i.e., technologies that have both military and commercial use), so as to take advantage of new technologies and their associated commercial cost efficiencies. Deputy Assistant Secretary of the Army (Research and Technology) Singley has also stressed these concerns in his outline in the Army Science and Technology Strategy (1994), along with the need to attract and develop quality scientists and engineers. I will discuss a program on how the Services could develop more scientists and engineers later in the paper.

If the philosophy of dual use (Alic, Branscomb, Lewis, Brooks, Carter and Epstein, 1992; Carr, 1993; Defense Science & Technology Strategy, 1994; Federal Acquisition Streamlining Act (1994); Stern, 1994; Sutton, 1994; Toffler and Toffler, 1993) is to play an increasing role in military systems, then we in the military need to look for ways to provide continuous feedback and dialog between the researchers, the manufacturers and the Program Managers (PM's); so as to shape the required products to a form that would be usable for both the military and commercial applications. Several ways that this might be achieved will be discussed later in detail.

Further, the military can no longer afford the "stove pipe development process" in which the design for a system is frozen at the R&D stage and proceeds to production. Rather, one needs to adopt the practice of constantly improving the product, and pursuing R&D in parallel with production, so as to feed in new technologies incrementally (STAR21 paper, 1994). This approach assumes the use of computer tools/designs in the development process, such as computer-aided software engineering (CASE) methods, enabling shortened production cycles, greater flexibility, and lower costs for the items.

I like the comment made by Dr. Mary Good (1993), Under Secretary of Commerce for Technology, that "from firsthand experience, both as a research scientist and as a corporate research manager, that there is no better prescription for failure than viewing the technology commercialization process as a relay race in which the athletes think they have done their job by running their lap and passing the baton off to someone else. Scientists in the lab cannot just toss some new prototype over the transom to the engineers to figure out what to do with it, who will then toss it over their transom to the marketing staff to figure out how to sell it." In conjunction with Dr. Good's comments, research indicates that "there is no assurance that the patents acquired, and the licenses obtained, will lead sequentially to commercial products. Far from it, the literature is replete with examples showing that the conversion of an invention to commercially usable technology requires substantial additional research in the form of technology development over an extended period of time (Kline and Rosenberg, 1986; Noble, 1990).

With the industrial world becoming more competitive, it becomes less likely that the U.S. will have quantum technological advantages over our adversaries, since they will also have access to the same basic technologies that are developed in the commercial market (Toffler and Toffler, 1993). This problem will be further exasperated by increased sales of arms to foreign governments, to defray costs for domestic defense contractors (Vartabedian, 1994). Rather,

competitive advantages will be gained now and in the future, by using continuous incremental innovation in products, processes and techniques vs. replacing existing equipment. Thus, the military in the future will grow increasingly dependent on the commercial sector, and the health of that sector (i.e., their capability to grow and develop new supporting companies) to maintain our leading edge in technology. These suggestions are in line with the Packard Commission recommendations (1986) and STAR21 paper (1994) which suggested DoD make greater use of components, systems, and services available "off-the-shelf," noting that the process of procuring microchips made to military specifications involved a substantial delay to system development and additional cost. As a consequence, military microchips lagged behind their commercial market counterparts by three-to-five years, thus affecting their "state-of-the-art" performance capability/edge over our potential adversaries' capabilities. The Services have already implemented this philosophy (Cooper, 1994), with the relaxing of mil-specs on systems.

In software development, computer-aided design (CAD) systems should be more widely used, so that they can facilitate the production of engineering drawings for mechanical parts and components, along with electrical wiring diagrams. Computerized databases on part drawings and specifications ensure that changes during engineering development can be quickly adapted and adjusted for weapons systems. Computer aided manufacturing (CAM) and computer aided process planning (CAPP) should also be promoted, with the eventual goal of computer integrated manufacturing that will combine all these functions into one.

It appears that it would be to the Services' and DOD's best interest to facilitate and interact with this process of technology transfer, and in so doing act as a catalyst for assisting industry to upgrade and expand their capabilities, and make available emerging technologies for our weapons/communications systems (Defense Science & Technology Strategy, 1994). To that end, I would like to expand upon some ideas on how and what the Services might do to facilitate this process, and what linkages could be developed between existing R&D-incubator-Project/Program Managers offices (PM's) to bring these technological advancements and skills into our weapons systems.

These programs would change the focus of some current funding to universities, from basic research, to promotion, development and transfer of technology and information, using the university as the principal agent for the process. These programs would increase the bi-directional discussion between the program manager (PM) user and the commercial technology developer, so that there would be continuous dialog with one another during the development process. This would clarify perceptions as to the intended use of the product, and aid in determining the standards required for the product, early in the product's development cycle.

Expanding upon the University's Potential

If, as a country, we are to improve our industrial competitiveness and assure that we have continuing improvement in our military technology in the future, the military needs to plant the seeds for those future researchers and scientists in the educators' and students of today (Alic, 1990; Benson, 1994). As Paul Kennedy and Lester Thurow (Kennedy, 1993 and Thurow, 1993) point out, relative to the rest of the world, we produce too few engineers and scientists; and this

trend is accelerating with U.S. universities now producing only half the Ph.D. engineers and scientists per capita that it did in the early 1970's. For instance, only 15-17% of our graduate students are engineers or scientists, compared to 40% in Germany and Japan (Thurow, 1993). Further, the majority of current funding to universities is for theoretical or basic research, rather than support for applied and mechanical/manufacturing research (Tesar, 1994). The lack of funding for applied research is evidenced by several negative trends, such as the increasing lead that Japanese machine tool accuracy and reliability have over our products (12.5 to 30 times better), and the worsening of our import-export ratio on mechanical and electrical manufactured systems (Tesar, 1992). Currently, the Services sponsor research through the Centers of Excellence Programs and through the OSD funded University Research Initiatives. These programs are expanding somewhat to now also include joint university-industry research projects (Gaumond, 1994), and the Army Research Laboratory's "Federated Laboratory" concept (Army Research Laboratory, 1994). ARPA is also funding engineering programs though their TRP initiative mentioned earlier; these are in conjunction with the National Science Foundation (Wax, 1995). Through these programs, the Services leverage the best universities in the nation to advance the state of science in areas of interest to the military. However, universities also need to develop a climate that can promote and generate the spin-off of these new technologies through assisting start-up technology firms, finding R&D funds, coordinating scientific personnel, and developing linkages with both military PM's and private industry. To that end, two trial university-centered programs might be established to facilitate the technology transfer process, and capitalize on the vast research opportunities that are available in our universities.

Technology Transfer Centers for Applied Engineering

Propose the development of Technology Transfer Centers for Applied Engineering. These centers would provide training and consulting at major universities to support technology transfer. These centers would be multi-year programs, where each year multiple teams would be formed, consisting of four masters students and two undergraduates. The masters students would consist of an Acquisition Corps student, an industry sponsored student, and two regular university students from the engineering department. Optimally, there would be two or three tenured professors (i.e., a full and an associate professor(s)), established at each university center over time, with their associated project teams. Each team would have a different research project, so as to not have any problems with the industry sponsoring the project feeling that its technologies or projects might be compromised. The research topic for the students would be suggested by the industry providing the student, and meet one of the research goals outlined by the Service Chiefs of Staff in their yearly outlines. Since the masters degree program would run a year-and-a-half, the research project would be geared for completion in a year or less. The degree in this program would be structured for a multi-disciplinary approach, borrowing from both engineering and business courses, so as to develop the student's ability to understand the many factors that come into play in taking an idea from the conceptual stage to manufacturing and marketing. It would hopefully also create a synergy between the students, so they would be able to draw on the strengths and skills of the different communities represented, and also enhance their understanding and appreciation for those other communities.

This program would serve as a basic building block to establish technology transfer in an area were substantial research is currently being performed but not fully utilized, promote dialog between all the development players, and act as an information evaluation/dissemination function for both the Services and industry. The benefits of this program would be:

1. Appreciation and understanding of the concerns and constraints of the different players in the development world (Military, University and Industry).

2. Provide both the Services and Industry with an applied engineering program to address specific research/engineering problems, and train new engineers and researchers for the future.

3. Provide industry with both advanced knowledge and laboratory resources that may not be available to them through their existing framework.

4. Serve as an information resource for PM's, the Research Laboratories and private industry, whereby specific engineering concerns could be addressed to our centers, and the professors there could investigate/evaluate the concern or application questions, and, if necessary, refer them to a specialist in that area. Further, the centers' professors would not only keep track of other research being performed at the university, but would also keep abreast of research projects at the main federal laboratories for their areas, and also ongoing Research Laboratory projects (Schatz, 1992; Werner, 1994).

5. Minimal cost to implement and support. In that the only new costs to the Army for these centers would be the professors' salaries, since the Services are already incurring the cost for sending students for advanced degrees (Masters of Business and Engineering) through either the Acquisition Corps or other degree programs. The universities would be expected to provide the facilities and support staff for the program and cover any other overhead expenses required (fringe benefits and indirect costs). Industry would be expected to pay for their students, and also contribute funding for the research they wish to perform and its associated costs such as travel, along with funding for the student fellowships. Thus, the cost burdens of the program would be distributed across the Services, the University and Industry.

Program specifics:

1. The selection criteria for universities to participate in this program would be that they would already have some type of technology transfer program in operation, such as a business incubator, or network of advisory services.

2. The professors would be tenured associate and full professors, so that they would have solid experience in science and engineering. The associate professors would serve in this program for four-to-six years, similar to working on a special project at a university. This would be in keeping with normal university personnel procedures and time constraints, while the full professor and his secretary would provide continuity for the program over time. An additional rationale for specifying a full professor was based upon the university's promotion requirements, where assistant and associate professors have to be worried about publishing and performing their own research in order to advance within the university. Because these positions would not provide these usual academic status requirements, they could hinder a "junior" professor's advancement.

3. An annual report would be provided by the professors detailing the assistance they had provided to the Services and industry in the preceding year, and describing their research projects and their possible uses, and their support of Service goals. Further, the professors would be

required to provide a quarterly briefing to Services and interested industry personnel on current research projects at the university that might be relevant, or have application to military programs.

4. The Master's degree for the program would be an engineering degree with a multi-disciplinary focus, stressing applied engineering and business processes. The one-and-a-half-year program would be as follows:

Summer Semester: the students would take two graduate courses in basic engineering to bring them up to a common level of engineering understanding, since some may have had electrical engineering experience and others mechanical. One of these courses would be a team bonding/building exercise to expose the research team to the problems of technology transfer, entrepreneurship and business methods, before they start their research project in the Fall Semester.

Fall Semester: the students would take three core applied engineering courses and start their research project under the direction of their professor. These courses might be in such areas as electromagnetic fields, electromechanical dynamics, advanced machine design, numerical methods, material processing, electronic machinery and magnetic devices, or studies in dynamic systems; depending upon the type of research project the team will be working on.

Spring Semester: the students would take one additional core applied engineering course, perhaps related to manufacturing processes such as systems engineering, modeling or intro to manufacturing systems, and two courses in technology transfer that would cover business practices specific to small entrepreneurs that would cover such areas as marketing, accounting, management, and sales; continuing to work on their research project.

Summer Semester: the students would take either an engineering course on manufacturing techniques, or a technology transfer course, perhaps addressing legal and venture capital concerns; and finalize their research project and its report.

5. The Full Professor, in the first year, would work with one team on its research project, and lay the groundwork for the selection of the Associate Professor(s); and establish the center's procedures for tracking research at the university and in the major federal labs and Research Laboratories.

6. In the second year, the Full Professor would continue to work with one research team, supervise and provide guidance to the Associate Professor(s), and continue to be the focal point for Service and Industry questions. The Associate Professor would work with two research teams, and provide assistance to the Full Professor as necessary on focal point questions and other related center support.

7. Optimally, in the third year of the program additional Associate Professors would be added to the center, and they would likewise work with two teams.

8. As mentioned earlier, the costs for these programs would be spread across the Services, Industry and the University, all providing support and sharing in the expenses so as to make these programs affordable and beneficial to all the participants. It is further assumed that

the faculty and staff positions could be funded by the Services at a half-time rate, allowing the faculty members to continue to teach some courses in their departments.

9. Procedures and agreements for this program would be similar to those outlined in the Army Research Laboratory's Federated Laboratory announcement (Army Research Laboratory, 1994), but would not need to be as restrictive or require as much reporting as their projects, due to the nature of this program.

<u>Projected costs for a center:</u>

1st year, would perform one research project

	Services	Industry	University
Full Professor	$ 40K		$ 32K
Secretary	$ 15K		$ 14K
Two Masters' fellowships		$ 24K	
Two Undergraduate fellowships		$ 12K	
Total	***$ 55K***	***$ 36K***	***$ 46K***

2nd year and perhaps a minimal program, would perform three research projects per year

	Services	Industry	University
Full Professor	$ 40K		$ 32K
Secretary	$ 15K		$ 14K
Associate Professor	$ 30K		$ 24K
Six Masters' fellowships		$ 72K	
Six Undergraduate fellowships		$ 36K	
Total	***$ 85K***	***$ 108K***	***$ 70K***

3rd year and a full program, would perform five research projects per year

	Services	Industry	University
Full Professor	$ 40K		$ 32K
Secretary	$ 15K		$ 14K
Two Associate Professors	$ 60K		$ 48K
Ten Masters' fellowships		$ 120K	
Ten Undergraduate fellowships		$ 60K	
Total	***$ 115K***	***$ 180K***	***$ 94K***

As a trial case to see how the program might work and to iron out unforeseen problems, the program should probably be implemented at only one university for two-to-three years before it is applied to other universities. Further, since I have spoken extensively with the faculty at the University of Texas at Austin about the program and how it might work (Davis, 1995; Fair, 1995; Fox, 1995; Gibson, 1994; Kozmetsky, 1995; Mark, 1995; Szygenda, 1994; Tesar, 1995; Weldon, 1994), and they have an ongoing applied engineering program, technology transfer courses and a technology incubator in operation, they would seem like a logical place to start the program. In speaking with John Preston at MIT (1995), they plan to start offering engineering courses at MIT that would also provide business skills, so if the Services wanted to expand the program to two test sites, MIT would seem to also be a viable candidate.

University Technology Transfer Incubator Program

There have been some studies that indicate that lack of funding for small businesses is not a particular problem (i.e., Pentagon-commissioned Study, a General Accounting Office (GAO) study (LeSueur, 1994) and Florida and Smith, 1993). Perhaps, instead of providing direct federal funding to small business, the Services could provide them with other assistance, such as help in organizing, marketing and developing their products, as in an incubator or business advisory service (Brett, Gibson and Smilor, 1991; Farrell, 1994; Gibson and Smilor, 1991; Gibson and Rogers, 1994; Gibson and Harlan, 1994; Kilcrease, 1994; LaBerge, 1994; Maleck, 1987; McWilliams, 1994; Szygenda, 1994; Williams and Gibson, 1990). This would also get the Government out of the business of evaluating SBIR and Small Business Technology Transfer Programs (STTR) applications, which perhaps we are not particularly qualified to assess. By providing an incubator environment for these small technology firms, the Services would treat them all equally, getting away from the criticism of the Government selecting favorites, and allowing the private sector to provide funds for the companies "they" deem competitive and commercially viable.

Propose that the Services assist and expand existing university technology transfer centers/incubators to fully utilize the potential that exists at the university for new approaches in science and technology, and to aid new start-up technology firms. This could be done in conjunction with the above program, or as a separate program. Currently, several universities have started programs for technology transfer at their institutions. However, this has been a difficult task for them, just as it has been for the federal labs. For, the old paradigm of "make the technology available, and people will want to use it," has not, and does not seem to be the way to proceed. There needs to be an active interest by all parties to create a climate that fosters technology transfer (Wohlert, 1990). The Services can aid in this process by becoming a more aware and active participant in the promotion of new start-up companies. This program would act as a bridge between military needs and university R&D.

To assist universities in expanding in this area, the Services might provide fellowships to both undergraduate and graduate students, who would work with the incubator's or university fostered support organizations in technology transfer. Like the program mentioned above, these fellowships could be for $12K for masters level students and $6K for undergraduates. This would allow the universities who already have expressed an interest in technology transfer to expand their existing programs, and through these students increase the number of skilled facilitators in technology transfer process, so that they, in turn, could provide assistance to new incubators in the future. The number of fellowships at any university would be fairly small and could be defrayed by switching some funds from existing SBIR and TRP allotments, since these incubators would be serving the same purpose as the small business aid programs.

These incubators would also look to incorporate existing federal, state and local funding initiatives on promoting small business, which in 1988 represented $550 million to promote technological innovation (Peterson, 1993). For instance, New Jersey has a voucher program for businesses that have under $20M in revenue, whereby a $1000 voucher can be redeemed at any

New Jersey technical center to assist the business with performing research and technical assistance.

The benefits to the Services for supporting an incubator program would be:

1. It would take the government out of the business of selecting to whom to grant TPR and SBIR awards, for which the government may not be the best judge in determining the success of these types of programs. It would also remove the criticism that the Government might select "favorites" for these awards. For instance, the TRP program had some problems in its selection process for FY93, in that many companies did not submit what were considered "proper" proposals. As a result, those companies were not funded by the program. I have heard similar comments concerning SBIR applications. Thus, if a small company does not have a good proposal or grant writer, their application may be rejected. Further, there have been some criticisms during SBIR selection processes, that not enough weight is being given to the likelihood of commercialization and long term needs of technology. In support of this argument, Starobin (1994) stated that SBIR awards judged for their technological rather than business merit produced only one success in four. Lastly, by just providing money and not training to these small business firms, they still do not know in many cases how to develop and conduct marketing studies and/or develop business plans that are the prerequisite of a successful product's commercialization (Kozmetsky, 1994).

2. It would provide more viable technology firms for suppliers to the military, since they would not only have better business awareness, but also support from the private sector for their products.

The establishment of these two programs would benefit not only the Services and their need for continuing leading edge technology development, but would also provide a training base for new engineers and scientists for the service. To oversee the administration of these programs and act as a facilitator between them and the Services and their development commands, a program administer position should be established. This position could be at OSD or at the Service level. The individual would manage the programs, approve of the academic curriculum, and coordinate between the Commands and the two programs as to all personnel and research requirements. To facilitate the coordination of the programs with the Commands, each Command would appoint a senior engineer (14 or above) familiar with the programs under development at that Command, to serve as a point of contact. This individual would be responsible for reviewing the research projects under development within his Command, and reviewing the research projects in this program for application to his Command's program needs. He would also attend the briefings given by the programs, so he could remain abreast of what the schools were doing, and act as the focal point for his Command to our designated university personnel on technical coordination questions concerning ongoing development efforts. In conjunction with the Command's using this program's universities as technical resource centers, private industry and the Service Research Laboratories would also have access to the technical expertise resident at our centers.

Conclusions

In reviewing what the Federal Laboratories, Universities, and other DoD agencies were doing to promote technology transfer, I came to the conclusion that more needed to be done in tapping into the resources that exist in our major universities. As a result, I developed a unified program around what might be done at universities that could benefit the Services and also private industry. This program would be a joint program between the Services, Universities, and private industry, whereby two separate but related university based programs would attempt to facilitate technology transfer through either technology transfer centers for applied engineering training and consulting, and/or university technology transfer incubator programs. Under the applied engineering program, it would be funded jointly by the Services, private industry and the university, and would train students from the military, private industry and regular university programs in a master's degree program on applied engineering and business skills: to make engineers more aware of what is involved in the process of developing and marketing products. The second program, the university incubator program, would provide support to small technology firms in university incubators, and experience to business and engineering students on how a small business is developed and run. In addition, these programs would feed back information and technology to the Material Commands, the Research Laboratories and private industries, for use in their ongoing materiel development projects.

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